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METHODS OF REDUCING THE COST OF PRODUCING BEET SUGAR.

By

C. O. TOWNSEND,

Pathologist in Charge of Sugar-Beet Investigations, Bureau of Plant Industry.

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METHODS OF REDUCING THE COST OF PRODUCING BEET SUGAR.

By C. O. Townsend,
Pathologist in Charge of Sugar-Beet Investigations, Bureau of Plant Industry.

INTRODUCTION.

The first refined beet-root sugar produced in commercial quantity was made about one hundred years ago, at a cost of approximately 80 cents a pound. The cost of producing cane sugar was then somewhat higher than that of beet sugar. The amount of raw sugar extracted from the beet at that time varied from 4 to 6 per cent, and the amount of refined sugar obtained was from 1 to 2 per cent of the weight of the beet. The cost of producing an acre of beets was estimated at approximately $35, while the yield was from 6 to 25 tons per acre. When it is considered that upward of 15 pounds of refined sugar can be obtained at retail to-day for the original cost of manufacturing 1 pound of beet sugar it must be realized that many improvements have already been made in the quality of the beet, in cultural methods, and in factory operations, all of which have tended to reduce the cost of the finished product.

The advances that have been made in cultural methods have been offset to a very great extent by the increased cost of labor in this country, so that the actual reduction in the cost of producing beet sugar has been due to the improvement of the beet or to less expensive operations in extracting and refining the product. It appears, therefore, that there are three avenues through which the cost of producing beet sugar may be increased or diminished. This article will deal only with those methods for reducing the cost of beet sugar which bear directly or indirectly upon the improvement and production of the raw material—the sugar beet—while the questions connected with extracting and refining the sugar will be left to the sugar chemist and to the sugar engineer.

In this connection it may not be out of place to mention the possibilities of utilizing to greater advantage the by-products of the beet-sugar factory. The first beet-sugar factory built (1805) manufactured raw sugar, wine, spirits, and vinegar. After several years of successful operation, the owner of this factory stated that if the sugar paid only for operating the factory the enterprise would still be a success. He further reported that the utilization of the beet leaves and pulp enabled him to double the number of cattle on his farm, and the

manure thus produced greatly increased the yield of his wheat. Stockmen are rapidly coming to understand the value of beet pulp as a cattle food, while the possibilities of manufacturing alcohol, fusel oil, vinegar, fertilizers, etc., from the refuse molasses have already been demonstrated. It may be that the ever-increasing demand for cheaper sugar, and the constantly advancing possibilities of utilizing the by-products, may eventually place the manufacture of sugar in that class of industries in which the factories are operated for the sake of the by-products. However, that time is far distant, and if the onward progress of this new industry is to be maintained the manufacture of sugar for sugar's sake must be fostered.

THE IMPROVEMENT OF THE BEET.

INCREASING THE SIZE OF THE BEET.

One of the most promising lines along which the cost of producing beet sugar may be reduced, so far as the question relates to the raw material, is that of the improvement of the beet. When one examines the wild beet and notes that the roots weigh but a few ounces each, he can not help wondering at the large tonnage that was sometimes produced early in the nineteenth century, when according to published reports the yield frequently reached 25 tons of roots per acre. It is true that the average yield was much below this point, but it undoubtedly compared very favorably with the present average yield of beets in this country, which according to obtainable figures is from 8 to 10 tons per acre. It would appear, therefore, that little progress has been made along this line. That the individual roots of the cultivated beet are larger than those of the wild beet there is no question; but it would seem from a study of comparative yields that the larger the root the fewer the beets which can be produced per acre. This is undoubtedly true within certain limits; but, after the most satisfactory relation between the number of beets per acre and the size of the beets has been determined, there are three methods by which the yield of beets per acre may be increased without diminishing the percentage of sugar in the beet: (1) By improved cultural methods; (2) by the use of fertilizers; and (3) by selection.

In regard to cultural methods used with sugar beets our foremost agriculturists do not agree. They are unanimous, however, in regard to the importance of early thinning. Undoubtedly many tons of beets are lost to the farmers and to the factories annually by delaying this important operation. In the use of other cultural methods we are constantly gaining new information through our experiments and through the growers' experience, which must eventually result in an increased tonnage of beets.

Thorough cultivation can not be too strongly emphasized as a factor in producing good sugar beets. It is a common saying among the

Germans that "the sugar must be hoed into the beet." While it is true that the sunshine and the air are the principal factors in sugar production, the cultivator and the hoe are important aids in keeping the beet vigorous and active. At no time in its life should a beet be allowed to cease growing, for if it once becomes stunted it is doubtful whether it will ever make as good a beet as it would have been under conditions of continuous growth.

Numerous experiments have been conducted by the United States Department of Agriculture, by the State experiment stations, and by growers to determine the proper relation between fertilizers and the sugar-beet crop. While there is still much to be learned in regard to fertilizers, there can be no doubt about the benefit to be derived from their judicious use with sugar beets.

The rotation of crops is an important matter in the growing of sugar beets, and while the rotations must necessarily vary in different localities there should always be some green crop in the rotation, preferably a legume, that can be plowed under to furnish humus and to supply at least a part of the nitrogen.

Having done everything possible by means of cultural methods and by the use of fertilizers of different kinds, there are still promising possibilities in the selection method. By this process, in which experiments are already under way in the Bureau of Plant Industry, it is proposed to select for seed production large beets rich in sugar, and by repeated selection and crossing to produce a strain of beets that will greatly increase the yield without any decrease in the sugar content of the beets. The results should be a much larger quantity of sugar per acre without any increase in the cost of production.

INCREASING THE SUGAR CONTENT.

Another possibility of improving the beet is to increase its sugar content. If this is done, even without increasing the size of the beet, a greater yield of sugar per acre may be obtained. When the percentage of sugar obtained from the beet a century ago is compared with the present sugar content of our cultivated beets, it is seen that much progress has already been made in improving the beet in this direction. A comparison of the average percentage of sugar actually obtained from the beet with the high sugar content of the best samples indicates that there is still opportunity to greatly increase the average sugar content of our beets.

If a largely increased yield of beets is combined with a much higher sugar content it is entirely possible to obtain three times as much sugar per acre as is produced on an average at the present time. For example, the present average yield of beets per acre in the United States is about 10 tons, and the percentage of sugar actually extracted and refined does not exceed 12, making the average yield of sugar per

acre approximately 2,400 pounds. Yields of more than 30 tons of beets per acre are sometimes obtained, and yields of more than 20 tons are common. From 20 to 25 per cent of sugar in the beets has been reported so frequently that it is safe to assume that an average sugar content of 18 per cent is within the limits of possibility. If an average yield of 20 tons per acre and an average sugar content of 18 per cent could be reached, we would have an average yield of 7,200 pounds of sugar per acre. If this could be realized without increasing the cost of growing the beets, it should be entirely possible for the grower to furnish the raw material to the factory at a somewhat lower cost than is at present practicable. This is the first important step toward reducing the cost of sugar production.

One of the most important factors in producing a beet rich in sugar is the proper selection of beets for seed production. This is the seedsman's problem, and is, under the present methods of beet-seed production, entirely outside the province of the grower of factory beets. However, the sugar content of beet roots depends to a very great extent upon the soil and climatic conditions. For example, in 1903 the Bureau of Plant Industry planted several varieties of sugar-beet seed on the Arlington Experimental Farm, near Washington. This seed was produced from beets that tested from 16 to 18 per cent of sugar. The beets grown from the seed tested in no case more than 12 per cent of sugar, and nearly all the samples tested less than 10 per cent. These beets were sent to Utah and planted for seed in 1904. The beets grown in 1905 from the seed produced from these roots tested 16 to 17 per cent of sugar. It will be seen, therefore, that while the beet still possessed the tendency to produce a high sugar content, the soil and climatic conditions in the vicinity of Washington, D. C., in 1903 kept the sugar production too low for practical purposes.

If the climatic conditions in any locality appear to be unfavorable for sugar-beet production, it is not advisable to undertake to grow sugar beets on a commercial scale until a beet has been developed by selection or otherwise that is adapted to that particular locality. It has been found that clay loams and sandy loams are very satisfactory for sugar-beet production, provided other conditions are favorable; but more depends upon the physical condition of the soil and upon methods of cultivation than upon the particular kind or variety of soil used. The soil should be well supplied with humus and well drained.

COST OF GROWING BEETS.

LAND VALUES.

In considering the methods by which beet sugar may be produced at a smaller cost so far as the raw material is concerned, there are certain factors which tend to increase rather than to diminish the cost of production. One of these is the increase of land values. During

the past decade there has been a remarkable advance in the price of farming lands, especially in those localities where beet-sugar factories are in successful operation. These lands have become more valuable not only because they produce large quantities of sugar beets, but because there is a ready market for the crop and because other valuable crops form with the sugar beets a very satisfactory rotation. There are thousands of acres of good farming lands where sugar beets may be grown with profit as soon as sugar factories are constructed.

Five years ago the land in a certain valley in Utah was offered for sale at $20 an acre. Since that time a sugar factory has been built, and from 6,000 to 8,000 acres of sugar beets are grown in that valley annually, bringing to the owners a return of $75 and upward per acre. As a result, practically none of the land is for sale at the present time. If by force of circumstances a tract of this land changes hands, the price obtained is $100 or more per acre.

In some parts of Colorado sugar beets, potatoes, and alfalfa form a rotation series to which small grains are sometimes added. When it is realized that potatoes often yield from 600 to 800 bushels per acre and sugar beets upward of 20 tons per acre, it is not surprising that this land is held at several hundred dollars per acre; and it may be stated that in none of the sugar-beet areas is the price of land decreasing.

The theory that sugar beets will ruin the land has long since been exploded. The best crops of sugar beets and other farm products are found on many of the farms where sugar beets have been grown longest. This is in part due to the fact that good farmers have become better farmers through their experience in growing beets. Proper rotation of crops, good cultivation, and the judicious use of fertilizers are the factors that keep the land in good condition and enable farmers to obtain the highest possible returns for the labor and money invested. The situation in regard to land values, so far as they relate to sugar beets, may be stated as follows: Inasmuch as sugar beets require the best quality of soil and demand that it shall be in the highest state of cultivation to produce the best results, sugar beets must remain a comparatively high-priced crop, and any attempt to reduce their price must result either in producing an unsatisfactory crop or in eliminating sugar beets from the system of crop rotation in many localities.

COST OF LABOR.

Another factor which up to the present time has had a tendency to increase rather than to diminish the cost of sugar-beet production is the cost of labor. The price of farm labor, like land values, has increased materially within the past few years. This is especially true of hand labor for thinning, pulling, and topping beets. In view of the greatly increased cost within the past decade of nearly all the

necessaries of life, and with every indication that the cost of living will not be materially reduced in the near future, it can not reasonably be expected that farm wages will be appreciably lowered within the next few years, at least. It is clear that the increased cost of labor thus far has had a tendency to increase rather than to decrease the cost of beet sugar.

AMOUNT OF LABOR.

Another phase of the labor question should be considered in this connection, and that is the amount of labor required in growing an acre of beets in order to obtain the greatest profit from the crop. The average cost of growing and harvesting beets at present is estimated to be approximately $30 per acre. It would undoubtedly be poor economy to lessen the cost of growing beets by reducing the amount of labor per acre under the present conditions. There are some indications that a still larger expenditure of labor upon the crop would produce a much greater return. For example, several years ago one of the leading agricultural papers of this country offered a series of prizes for the best crop of sugar beets to be grown under certain conditions. One of the winners produced approximately 30 tons of beets on an acre of ground. The total cost of growing this acre of beets was nearly $60. A little reflection will show that a much larger profit per acre was obtained in producing 30 tons of beets on a given area at an outlay of $60 per acre than would have been made by spending $30 in growing the present average tonnage on the same area. From this and other examples that might be cited, the conclusion is obvious that the production of sugar per acre may be increased by increasing the amount of labor per acre in growing the beets.

SOURCES OF LABOR.

The question of obtaining a sufficient number of the right kind of laborers to grow the sugar-beet crop has become one of the most complex and at the same time one of the most important problems in connection with the sugar-beet industry in nearly all the beet areas in this country. Scarcity of labor has an important bearing upon the cost of sugar production in several ways, but especially in delaying the work and in leaving certain operations undone, thereby reducing the yield of sugar per acre.

In some localities no difficulty is experienced in obtaining a sufficient number of suitable laborers throughout the season, especially in those sections where the farms are small and the country is thickly settled with good farmers. Under these circumstances the individual farmer is usually found growing a small acreage of beets—frequently not more than from 3 to 10 acres—which he is able to care for with his own family, with possibly some assistance now and then from his neighbors. In this way beets are grown more satisfactorily as

regards labor than in any other. In most of our sugar-beet sections, however, it is necessary to depend to a greater or less extent upon outside help. Just how this labor is to be secured, how it is to be retained throughout the season, and how it can be made a permanent factor in the sugar-beet industry are problems upon the correct solution of which the future of the beet-sugar industry depends to a very great extent. Efforts are being made to work out these problems in the various localities where help is needed; and, while the conditions in the different sections are not identical, a brief review of some of the important methods used may be helpful.

In the Middle and Eastern States, and in some of the Western States, a large part of the labor in connection with sugar beets must be done during the summer, at which time a large number of pupils and teachers from the public schools are available for the work. Many growers take advantage of this fact, and hundreds of school children are employed annually in thinning, weeding, and hoeing beets. In some localities the teachers, both men and women, spend a part of the long vacation in the beet fields, much to their advantage physically as well as financially. When this kind of labor can be employed it is generally satisfactory, and improves from season to season with the experience gained. Unfortunately there is not enough of this kind of labor to supply the demand, and in a few localities it is reported unsatisfactory.

If the sugar-beet area is located near one or more large cities a considerable portion of the temporary labor comes from that class of city residents who have no permanent employment and who are willing to go out and work in the fields. This is especially true of certain members of the foreign population, both men and women, who often make excellent farm hands. Most of these laborers insist upon returning to their homes in the city at the close of the day. Numerous instances might be cited of Polish women who walk from 2 to 4 miles in the morning in order to do their day's work of thinning, hoeing, or topping beets, or other farm work that their employer may require. (Pl. XIII, fig. 1.) At the close of the day they walk back to their homes only to repeat the same operation the next day and each day throughout the season. Some of the employers state that this is the best class of labor that they are able to obtain on their farms.

Some of the laborers become very skillful at this kind of work; others were familiar with it before coming to this country and depend from the first upon finding employment of this kind. However, many of these laborers are seeking permanent employment in the factories and other enterprises in the city, so that this class of farm labor is in constant danger of depletion. At best this kind of labor is limited by the number of people who are willing to go out from

the city and do work of this kind, and also by the small number of farmers who are near enough to the city to allow the laborers to return home at the close of the day. If some of the farmers living farther away from the city could induce some of these families to become permanent residents of the rural districts it would undoubtedly be mutually beneficial in many cases. Various methods are being used in different places to accomplish this result. In one section where labor is scarce the officials of the sugar company suggested that each farmer build at least one tenant house for the accommodation of some of the labor required. The farmers are acting upon this suggestion, and undoubtedly within a few years this community will be well supplied with good labor.

It is well known that many families, especially those of foreign birth, hesitate about going into the country for the reason that they would, in a way, become practically isolated from their countrymen. In order to overcome this difficulty and at the same time to solve the labor problem for the sugar-beet industry, several sugar companies have purchased large tracts of land and have offered various inducements to laborers to settle upon the land in colonies. For example, one sugar company divided its land into small farms of 40 acres each, which were sold at a low price on easy terms. The only requirement was that the purchaser should grow a small acreage of sugar beets for at least two years, upon the presumption that if beets were grown for two years the purchaser would be a permanent grower. This plan, which was started four years ago, worked out satisfactorily. All the land was sold and each year upward of 6,000 acres of sugar beets are grown for the near-by factory.

In another sugar-beet section the sugar company has divided its land into small farms, which it has equipped with the necessary stock and tools and on which it has built comfortable houses. These places are rented to farmers, who are growing small areas of sugar beets. This plan is working satisfactorily for the sugar company and, like the preceding method, is of inestimable benefit to many families desirous of becoming independent citizens.

Still another sugar company has set apart a portion of its land with a view to forming a Russian colony. This land is divided into acre tracts, and a small house is built on each tract. Figure 6 shows four of these houses; that is, the two buildings shown consist of two houses each, placed side by side. These houses are rented to Russian families with the definite understanding that when a family has worked for the company a given number of years a deed for the house and lot will be given to that family. This plan is of comparatively recent origin, and the effect that it will have upon the solution of the labor question is still problematical. If there is any disadvantage in this plan over the preceding ones it undoubtedly lies in the fact that

the tract of land is not large enough to support a family; hence, the workers must seek employment on other farms, necessitating the expenditure of considerable time and energy in getting to and from their work.

In the same community another plan has been adopted which promises good results. The important point, the nucleus of this plan, is a portable house. The outfit, as shown in figure 7, consists of a farmer's handy wagon, the wheels of which are 28 inches in diameter and have a 5-inch tread. The construction of the house is shown in the cut. The outfit consists of a laundry stove, cooking utensils, woven-wire folding cots, mattresses, and blankets. Each house will accommodate from two to five workmen, and costs about $75. The laborers occupying one of these houses contract to do the hand work for several beet growers at a price ranging from $18 to $21 per acre, depending upon the number of hoeings, etc., included in the contract.

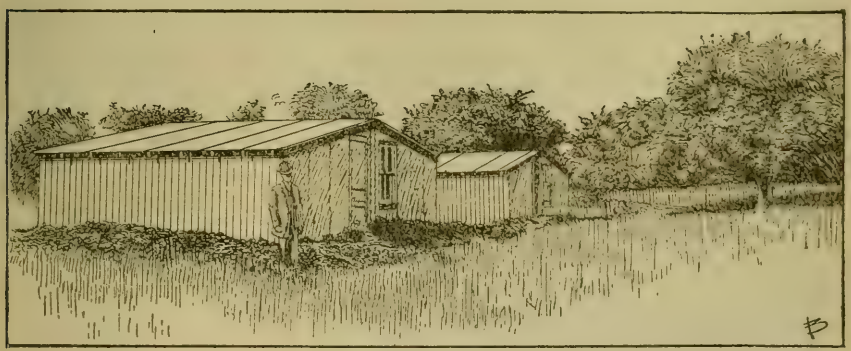

FIG. 6.—Laborers' houses, one to each acre tract—one method of solving the labor question in growing sugar beets.

The agreement is that when they have finished one operation, such as thinning, for one farmer, he will take his team and haul the house to the next farm. This house is portable, not only in the sense that it is on wheels, but also from the fact that it is capable of being taken down and shipped on the cars. In this way it is easily shifted about from community to community, to the place where it is most needed.

The laborers using these houses are mostly Belgians, who seem to be very satisfactory in the beet fields in most instances. They are tireless workers, and when employed by the acre often utilize every moment of daylight in caring for the beets under their contract. Their method of topping beets, as shown in Plate XIII, fig. 2, is one that seems to be peculiar to themselves, and is very rapid. The beets are pulled and thrown in rows, with the tops all one way, and then in a bent position, as shown in the illustration, the laborers go up and down the rows, cutting off the tops and throwing the beets into piles. The two brothers shown in the illustration were photographed in 1904

while working on one of their contracts. This year (1906) they rented 40-acre farm and are growing their own beets. It is safe to predict tha within a few years they will be landowners and employers of labor.

In still other communities large numbers of Japanese are employed fo sugar-beet work. For a given community the Japanese are usuall contracted for through their leader, who agrees under bond to furnis so many laborers for the hand work at some stipulated price. Thi price is about the same in all the sugar-beet sections—$20 per acre This army of laborers, often consisting of several hundred under one contract, may be, and usually is, divided into smaller squads, which are sent to the various fields where they are needed. They usually form a camp in which they live by themselves. Under the direction of a competent foreman they are capable of doing excellent work, but

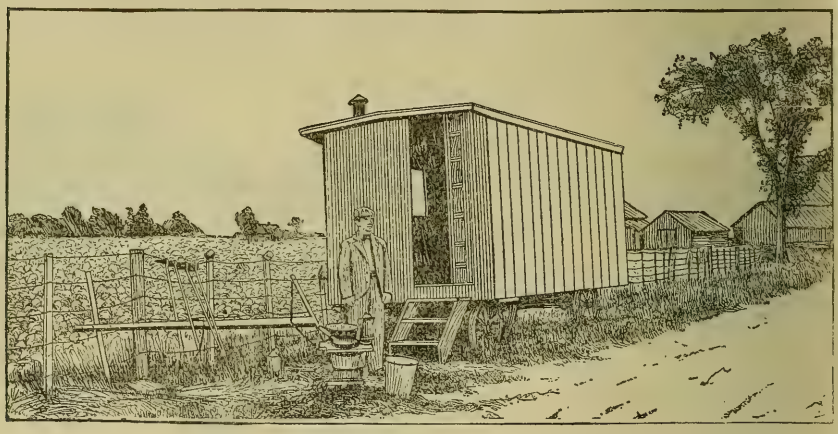

FIG. 7.—A portable house used in solving the labor problem in some parts of the sugar-beet area.

they sometimes become careless and trifling, in spite of everything that may be said or done.

Many growers in the West speak very highly of the Chinese as laborers in the sugar-beet fields, but owing to our present immigration laws they are necessarily very scarce, this being especially true of the younger and more active members of the race.

REDUCING THE COST OF LABOR.

The high price of labor, as well as its scarcity, has acted as an incentive to change the structure of beet seed and devise other means whereby sugar beets may be grown with less hand labor. While it has been shown that all the labor performed in producing a crop of beets is necessary in order to obtain the best results under present conditions, it may be possible to perform one or more of these various operations in some other manner with just as good or even better results than at present and at less expense. For example, the production of single-germ beet seed is but a method of thinning beets before the seed is planted.

FIG. 1.—POLISH WOMEN THINNING BEETS.

FIG. 2.—BELGIAN METHOD OF TOPPING BEETS.

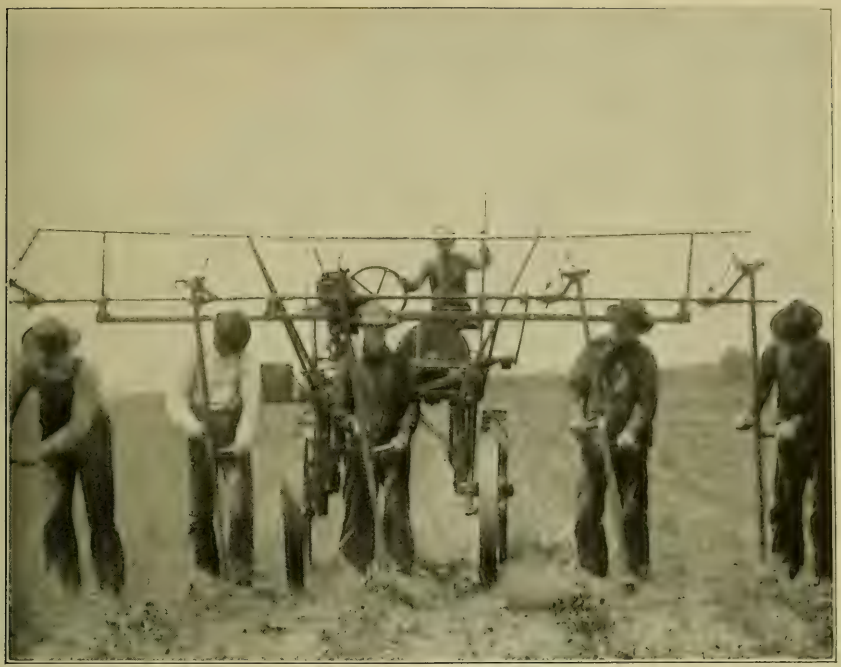

FIG. 1.—POWER HOE THAT MAY BE UTILIZED IN BLOCKING AND HOEING SUGAR BEETS.

FIG. 2.—SILOING SUGAR BEETS FOR THE FACTORY.

PRODUCTION OF SINGLE-GERM SEED.—Commercial beet seed consists for the most part of from two to seven individual seeds welded by nature into one mass. It is evident that plants produced from such a mass of seeds must necessarily be very close together, and thus far no mechanism has been devised whereby the plants can be properly thinned. It is clear, therefore, that if we expect to do away with the hand thinning of our sugar beets it can probably be accomplished only by changing the construction of the seed ball, either naturally or artificially, so that there will be but one germ in each ball. Repeated efforts have been made to break up the seed balls by passing them through various forms of rollers and grinders so that each seed could be planted by itself. The seed coats are so hard that any device that has been tried thus far that will crush or break the seed ball breaks a large number of the seeds and renders them useless.

An effort is being made by the Bureau of Plant Industry to produce a single-germ beet seed by selection. The results of this work up to the close of last season (1905) are reported in Bulletin No. 73 of the Bureau of Plant Industry, in which it is shown that the percentage of single-germ seeds has been increased from less than 2 to upward of 25 per cent.[a] In the light of the advance that has already been made it is reasonably safe to assume that this object will finally be accomplished by this means. After a plant possessing single-germ seed balls has been produced it will necessarily be a number of years before a sufficient quantity of this seed can be produced so that it can be used commercially.

THINNING.—Meantime, as the industry grows, there will be an ever-increasing demand for hand labor for thinning the beets. Many growers have not yet learned the importance of early thinning, and consequently they try to do the work with an insufficient force, letting this operation, which should be done within a few days, extend over a period of several weeks, much to the detriment of the yield and consequently to the returns from the crop.

HOEING.—The number of hoeings given a crop of sugar beets varies from two to five. A single hoeing is much less expensive than the single operation of thinning or of harvesting, but the total number of hoeings, if properly done, will cost more than either of the other operations. It is important, therefore, that something be done to reduce the cost of hoeing sugar beets. As already pointed out, it would be poor economy to reduce the cost of hoeing beets by giving them a smaller number of hoeings or by doing the work less thoroughly. On the other hand, there are indications that better beets could be grown

[a] Since this paper was written the single-germ seeds produced in 1906 have been separated and counted, and it is found that several of the plants yielded upward of 49 per cent of single-germ seeds. A large number of the plants produced more than 30 per cent.

if more attention were given to this phase of sugar-beet culture. If anything is to be gained over the present method of hoeing beets it must be by means of a machine that will do the work more thoroughly or at a lower cost per acre. A power hoe has recently been invented and successfully used in the cotton fields. Although not yet tried in connection with sugar beets, it would seem from its construction that it could be used to considerable advantage in the beet fields. This hoe consists of a metal disk which may be forced into the ground to any desired depth, and is made to rotate rapidly in a plane parallel to the surface of the ground. The power that causes the disk to rotate is furnished by a gasoline engine, while the movement around the plant is guided by the human hand, as shown in the illustration. (See Pl. XIV, fig. 1.) It is claimed for this machine that from five to six times as much work can be done per day with one of these hoes as can be done by the same man with a hand hoe. If this particular implement is not adapted to sugar-beet work it will doubtless lead to something whereby artificial power may be used in blocking and hoeing sugar beets.

Cultivating.—Several cultivations are necessary in the growing season. The number of cultivations and the depth and distance from the beets that the teeth of the cultivator should operate are moot questions among agriculturists. It is agreed that different conditions require different treatments, and hence the expense of cultivating beets must depend somewhat upon soil and weather conditions. However, the single cultivator has given way to a great extent to the two-row cultivator, and recently a four-row cultivator has been devised and put in operation, so that the cost of each cultivation is greatly reduced. The initial cost of the four-row cultivator is greater than that of a single-row cultivator, but the additional outlay is soon made up if there is a considerable acreage of beets to be cared for.

Harvesting.—Harvesting sugar beets consists of three distinct operations, viz, lifting, pulling, and topping. For many years lifting or loosening the beets has been done by horse power. In some parts of the West steam power is now being used for this purpose. Two kinds of lifters are in general use, one consisting of a side plow, which passes along one side of the beet row and loosens each beet by pressing slightly against it and at the same time plowing it up. The other form might be described as a plow with two points or shoes, so arranged that as they pass along on either side of the beet row each individual beet is caught between the points and lifted slightly, so that it is left perfectly loose in the ground. The beets must then be pulled and topped by hand.

Many forms of beet harvesters have been constructed, but none has come into general use. It is the aim of the inventor of the beet harvester to perform the three operations at the same time.

Some inventors aim to top the beet and then pull it, while others maintain that the beet must be first pulled and then topped. If the beets are topped and afterwards pulled, there seems to be some difficulty about getting all of them out of the ground. On the other hand, if the beets are first pulled and then topped, considerable difficulty is experienced in topping them correctly, owing to the variation in the size of the beets and the difference in the length and size of the crowns. Several new harvesters are in the field this year (1906), and it is probably a question of only a few years when the harvester in the beet field will be as common as it is in the grain field. The cost of hand work in harvesting beets is from $5 to $8 per acre. It must be remembered that no machine annihilates the cost of any farming operation, but that a satisfactory beet harvester would greatly reduce the expense of harvesting the crop is evident.

TRANSPORTING TO FACTORY.—Another important factor in the cost of producing the raw material is the expense involved in transporting the beets from the farm to the factory. If the field is located near the factory and the roads are level and well made the beets may be delivered at a minimum cost. As the distance from the factory increases, more time is consumed, and consequently the expense is increased. The importance of good roads can not be overestimated. It frequently happens that the fall rains begin before the beets are delivered, and unless the roads are well made they are soon full of holes and ruts that make it impossible to haul more than half a load at a time, practically doubling the expense of delivering the crop. One effect of the sugar-beet industry is the improvement of the country roads, and conversely the improvement of the country roads is an aid to the sugar-beet industry.

Railroad facilities and rates play an important part in the cost of delivering the sugar-beet crop. Very few factories grow all their beets within hauling distance. The grower and sugar company are fortunate if the railroads so radiate from the vicinity of the factory that the beets grown in a given community can be brought in over one line of road. It is often the case, however, that the cars must be sent over two or more roads, which necessarily increases the expense. It too often happens that there is an insufficient supply of cars at the time they are wanted or the cars furnished are not adapted to handling sugar beets; consequently considerable time is lost in loading and unloading the beets. All these things are adjusting themselves gradually to the betterment of the industry through the persistent efforts of those interested.

DESTROYING WEEDS.—The improvement of farming methods has been mentioned as playing a significant part in sugar-beet growing. One point that should be emphasized in this connection is the importance of destroying weeds. This work should not be confined to the

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beet fields. Adjacent fields, roadsides, fence rov
should be watched and the weeds destroyed before they go to seed. It is not uncommon to find beet fields that are in fairly good condition while the roadside just over the fence is full of weeds. Some of the seeds of these weeds will certainly be scattered by various agencies over the field and be ready for growth the next year. The destruction of weeds for a single season will not always produce appreciable results, for the reason that a large number of weed seeds remain alive in the ground for a number of years. Persistent efforts in destroying weeds, however, will result after a few years in greatly reducing the labor of keeping beet fields free from these pests.

SILOING THE BEETS.—Another expense that must be reckoned with under certain circumstances is that of siloing the beets. This becomes necessary when the beets must be harvested faster than they can be handled at the factory. It will be seen at once that siloing the beets necessitates an extra handling of the crop, since they must be reloaded into the wagons and hauled to the factory or dumping station. Inasmuch as siloing factory beets has not yet come into general practice in all of the beet-growing localities, a fair idea of the methods employed and labor involved may be gained by referring to Plate XIV, figure 2. In addition to the extra expense involved, which varies from 20 cents to $1 a ton, there is more or less shrinkage in weight due to evaporation. To avoid the expense and loss incident to siloing the beets an effort is being made by the Bureau of Plant Industry to lengthen the harvesting season by producing an early-maturing beet. It is hoped by this means to so distribute the ripening period that the factory will be able to handle the beets as soon as they are harvested.

SUMMARY.

While the methods of cheapening the process of making beet sugar can not be adequately treated in a short article of this kind, the principal points to be aimed at may be summed up as follows:

(1) Increasing the tonnage without increasing cost of production.

(2) Improving the quality of the beets without additional expense.

(3) Improving the beet in size and quality, or both, at additional expense, but in such ratio that the gain is greater than the outlay.

(4) Providing a sufficient quantity of suitable labor at the proper time so that the beets may be kept growing without interruption.

(5) Modifying the beet seed so as to render thinning unnecessary.

(6) Modifying the beet so that siloing for the factory will not be necessary.

(7) Devising machinery that will do away with hand labor.

(8) Improving farming methods and operations so that less labor will be required to produce the crop.

(9) Improving wagon roads and railroad facilities.

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